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Environmental and Animal Benefits when Beef Cattle Consume Condensed and Hydrolysable Tannins

Elizabeth K. Stewart, Graduate Research Assistant, Wildland Resources,
Juan J. Villalba, Professor, Wildland Resources
Kerry A. Rood, Associate Professor, Animal, Dairy and Veterinary Sciences

Plants are composed of two types of compounds, termed primary and secondary. Primary compounds (e.g., carbohydrates and amino acids) are found in all plants and are essential components for growth, development and reproduction. Plant secondary compounds (PSCs) received this name when they were discovered in the second half of the 19th century when it was believed they were waste products of the plant's metabolism. However, we now know that, in contrast to this initial view, they are not waste products and they provide significant benefits to the plant. Plant secondary compounds are involved in interactions between plants and other organisms such as pathogens, pollinators, and herbivores and are therefore typically colorful or have a distinct taste or odor (Crozier et al., 2006). The functions of PSCs are diverse and include protecting the plant from pathogens, aiding in beneficial interactions with good bacteria, acting as sunscreen and antioxidants, transporting metals inside the plant (Demain and Fang, 2000), and discouraging herbivores from eating the plant (Waghorn, 2008). The specific function of PSCs differs depending on their chemical structure and the plant species.

Tannins are a kind of PSC that can be classified into two main types: condensed tannins (CT) and hydrolysable tannins (HT). Both types can have beneficial effects on beef cattle and the environment.

Condensed Tannins

Condensed tannins are naturally occurring PSCs and occur in varying forms and concentrations in many different plant species and some forage species that can be fed to livestock. Examples of these forages are birdsfoot trefoil (Fig. 1), which contains low levels of CT, and sainfoin (Fig. 2), which typically contains greater CT concentrations.

Condensed tannins cause astringency when eaten due to their ability to bind with proteins in the saliva resulting in a dry, bitter taste (Kumar and Singh, 1984) which discourages animals from consuming the plants. However, there are certain species of plants that contain CT in low concentrations or with

Figure 1. Birdsfoot trefoil is a perennial legume and is easily identifiable by its bright yellow flowers.

Figure 2. Sainfoin is a tall growing, perennial legume with light purple flowers.

a specific chemical structure that do not seem to reduce palatability or intake. This opens the door for herbivores to benefit from consuming plants that contain CT.

Condensed tannins have the ability to reduce internal parasite loads and reduce the risk of bloat in ruminant herbivores (Waghorn, 1990). Additionally, CT can help improve utilization of protein in beef cattle because they bind with the proteins in the rumen, releasing the protein later on in the small intestine (Bunglavan and Dutta, 2013). This process increases the rumen bypass protein and increases the amount of high-quality protein available to the animal for absorption, which is important because cattle are generally inefficient at utilizing the protein that is provided to them in their diets.

Methane is produced in substantial amounts as a by-product of the normal digestion process in beef cattle. However, methane production is wasteful in terms of energy production. Condensed tannins have been shown to reduce the amount of methane produced by ruminants (Carulla et al., 2005; Fig. 3). This is significant because reductions in methane production translate into increased efficiency of energy utilization by cattle.

Condensed tannins can also help to mitigate the negative environmental impacts resulting from beef cattle, which are responsible for the production of three greenhouse gasses: carbon dioxide, methane and nitrous oxide. Methane and nitrous oxide are a bigger concern because – although they are produced by cattle in smaller amounts than carbon

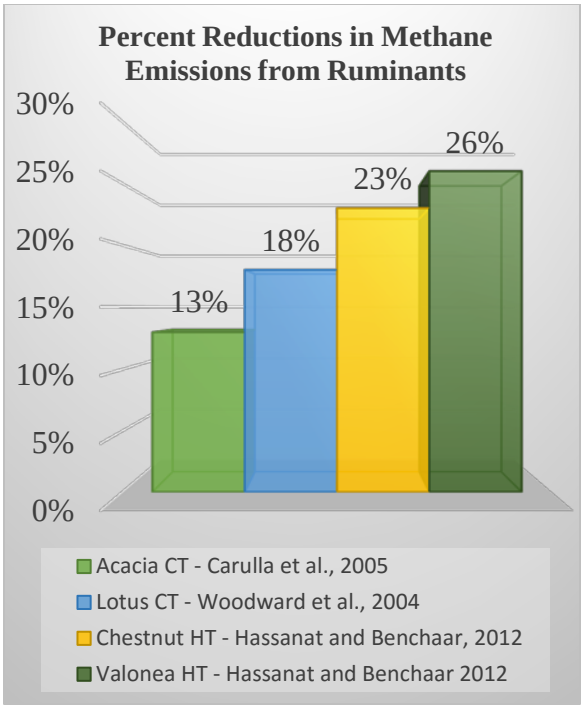

Figure 3. Methane emissions are significantly reduced by both condensed and hydrolysable tannins.

dioxide – they have greater global warming potentials, so a smaller amount can do more damage (Fig. 4). Methane production is a by-product of the normal digestion process and nitrous oxide results from the inefficient utilization of protein. Much of the protein fed to cattle is excreted in the urine and feces and 1 – 2% of the excreted nitrogen is

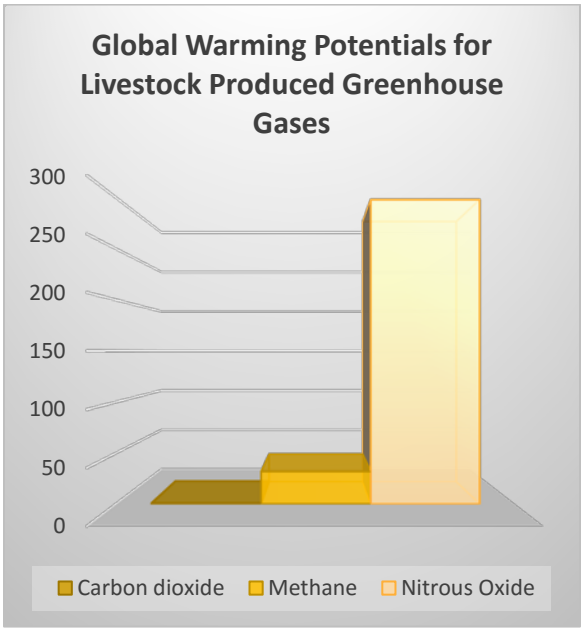

Figure 4. Carbon dioxide has a global warming potential of 1, while the global warming potential of methane is 32 and nitrous oxide is 298.

transformed into nitrous oxide (Oenema et al., 2005). The good news is that CT have the potential to reduce both methane emissions and the concentration of urea wasted in the urine (Carulla et al., 2005).

Hydrolysable Tannins

Hydrolysable tannins occur naturally in a variety of plants including chestnut trees and blackberry bushes. The forb small burnet (Fig. 5) also contains hydrolysable tannins and can be used as a forage species component for beef cattle diets.

Figure 5. Small burnet is a forb with small purple flowers.

In contrast to CT, which are resistant to hydrolysis, hydrolysable tannins (HT) are easily hydrolyzed by acids or enzymes. Like CT, however, HT may also act as deterrents by reducing palatability and thus the intake of plants that contain them. Nevertheless, HT also reduce methane emissions from beef cattle (Hassanat and Benchaar, 2012; Fig. 3) and digestion of protein in the rumen (Hervas et al., 2000), leading to less urea excreted in the urine and subsequently, less nitrous oxide emitted into the atmosphere.

Due to their ability to reduce methane production in the rumen, HT can increase the amount of energy available to the animal. However, HT appear to have more negative post-ingestive consequences to ruminant consumers than CT do. These include decreased intake (Verheyden-Tixier and Duncan, 2000), and increased antimicrobial activity (Ekambaram et al., 2016) leading to reduced digestibility. In addition, ruminal microbes can break HT down into compounds that can be absorbed from the rumen and lead to toxicity (Reed, 1995). In contrast, CT are larger molecules, less soluble in water, and are considered to be non-toxic because they are not absorbed through the gastrointestinal tract.

Producer Concerns

It is important to remember that the concentration of tannins will vary based on the species of plant being considered. Also, while the benefits to the environment from both CT and HT are clear, HT seem to have fewer direct benefits to the cattle consuming them. Forage species containing CT and HT have received less attention than conventional forages (i.e., alfalfa and tall fescue) and thus varieties currently available to producers do not present comparable agronomic advantages in terms of establishment, persistence or productivity. However, it may be possible to incorporate such “non-traditional” varieties as a complement (e.g. in strips or in small paddocks) to the more traditional forage species instead of replacing them. In this way, producers can take advantage of the many benefits of CT and HT in their grazing systems. In the future, breeding programs should turn their attention to these “non-traditional” forage species to provide more adaptable, productive and resilient cultivars to the market.

Photo Credits

[1]Image courtesy of David Cappaert (http://articles.extension.org/pages/65812/lotus-corniculatus-birdsfoot-trefoil)

[2]Image courtesy of Ralph Pearce (https://www.country-guide.ca/2015/05/20/sainfoin-a-new-forage-legume-for-ontario-livestock-producers/46694/)

[4]Figure adapted using data from Carulla et al., 2005, and Hassanat and Benchaar, 2012.

[5]Image courtesy of the USDA (https://plants.usda.gov/core/profile?symbol=sami3)

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